Extended Abstracts of the 2004 International Conference on Solid State Devices and Materials, Tokyo, 2004, pp. 674-675

P13-2

Interface Modification in Organic Thin Film Transistors

Bo-Tan Wu; Yan-Kuin Su ;An-Chang Wang;Ming-Lung Tu;You Sian Chen

National Cheng Kung University, Institute of Microelectronics, Department of Electrical Engineering,
Tainan 701, Taiwan, Republic of China, Tainan 701 Taiwan
Phone:886-62757575-62400 ext.281 Fax:886-62351864
E-mail:Q1690403@mail.grad.ncku.edu.tw

1. Introduction

Organic materials are generally used in many electrical devices like as light emitting diodes [1], thin film transistors [2-3], and photo-detectors [4]. Due to variety of materials, fabrication methods, and amazing characteristics, the organic electrical devices attract many researchers to jump into this field. For organic thin film transistors, many different materials, structures, and special modification methods were used to improve the characteristics of devices. Nowadays, the characteristics of OTFT were almost the same as amorphous silicon (A-Si) which was commonly adapted in the modern liquid crystal display (LCD). In this report, octadecyltrichlorosilane (OTS) with different solvents was used to modify the interface of organic and dielectric layers in OTFT.

2. Experimental

The top contact structure like as Fig 1 was used in this experiment. The high doping n-type silicon was used as subtract and gate electrode. A 3000A thickness silicon dioxide was the dielectric layer grown by thermal oxidation. Before depositing organic layer (pentacene), the surface of silicon dioxide was treated with OTS solutions (1% volume concentration) for 24 hr which were prepared with three different solvents (Hexadecane, toluene, and ethanol).Then Pentacene was deposited as the active layer obtained from Aldrich without purification. Above pentacene, gold was deposited as drain and source electrodes. All electrical characteristics were measured with Keithley 4200.

3. Results and discussion

The effects of OTS were revealed in many papers [5-6]. In this paper, the different phenomenon was observed from the electrical characteristics of OTFT. From Fig 2, the on-current (Ion) of the devices which were treated with OTS (1%) in hexadecane and toluene were larger than no treatment and in ethanol. This result was consisting with other's experiments that OTS would enhance the crystallization of organic thin film and the effective mobility of the devices. But it seemed that OTS in the ethanol didn't work. In this experiment, the mobility was enhanced about 10 times reaching to 0.35 $cm^2/V*s$. From Fig 3, the intensity of the X-ray diffraction had almost the same trend as the mobility of OTFT.

On the other hand, the off-current (Ioff) of OTFT would be lowed down about two decades after treating with OTS solution. The devices with treatment had very small off current reaching to 10^{-10} Ampere. It meant that the device could reduce the power consumption when operated in the off-state. Moreover, the subthreshold slope of the devices had been reduced from 17.4 V/decade to 2.8 V/decade. The OTFT with low subthreshold slope could be operated at higher speed and also lose less power.

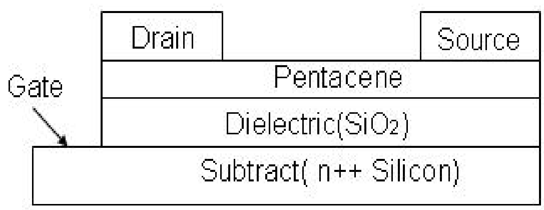

Fig 1

Top contact structure of OTFT

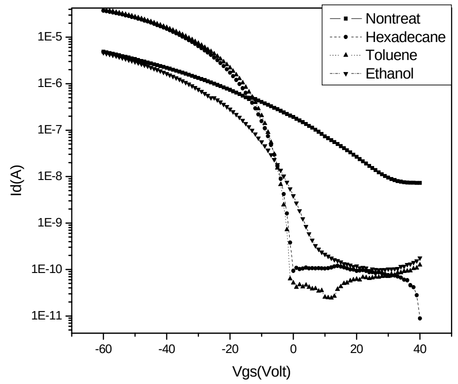

Fig 2 Id-Vgs characteristics OTFT

Square-without treatment; Circle –OTS in hexadecane

Upper Triangle-OTS in toluene; Down Triangle-OTS in ethanol

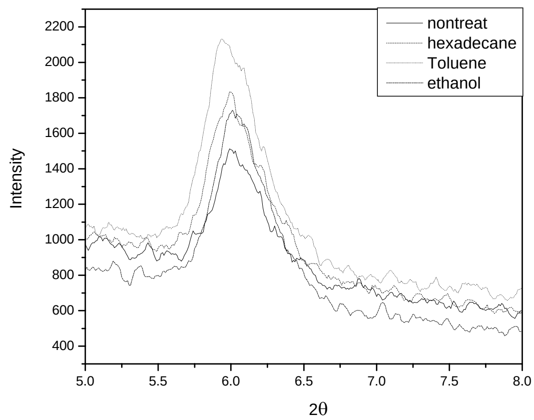

Fig 3

XRD measurement of pentacene thin film on silicon dioxide

4. Conclusion

In this research, the interface modification was used to enhance the electrical characteristics of OTFT. The OTS solutions with three solvents were adapted to treat the surface of silicon dioxide. The optima mobility of the devices reached to 0.35 $cm^2/V*s$ which were treated with OTS in hexadecane or toluene. It would be increased about 10 times comparing to the devices without treatment. On the other hand, off-current (Ioff) of the devices had been lowed down about two decades. The best ratio of Ion and Ioff was about 10^6. This phenomenon was seldom mentioned before. The substhreshold slope of the devices treated in the OTS with hexadecane and toluene were reduced from17.4 V/decade to 2.8 V/decade.

References

[1] Sheats J.R, Antoniadis H, Hueschen M, Leonard W, Miller J, Moon R, Roitman D, Stocking A, Science 273 p884, 1996.

[2] Dimitrikopoulos C. O, Mascaro D.J, , IBM J.Res. & Dev. Vol 45(1) pp11-27, 2001.

[3]H. Fuchigami, A. Tsumura, and H. Koezuka,, Appl. Phys. Lett. **63**, 1372 (1993)

[4] P. Peumans and S. R. Forrest,Appl Phys. Lett.**79**,126(2001)

[5]David J. Gundlach, LiLi Jia ,Thomas N. Jackson,,IEEE Electron Device Letters, vol. 22, No. 12.

[6] Jiangeng Xue and Stephen R. Forrest, Appl Phys. Lett., 79,3174(2001)